

(2)

AD-A224 027

IDA MEMORANDUM REPORT M-376

Ada VALIDATION WORKLOAD

Audrey A. Hook
R. Danford Lehman

January 1988

DTIC
ELECTED
JUL 11 1990
S B D

Prepared for
Ada Joint Program Office

DISTRIBUTION STATEMENT A

Approved for public release;
Distribution Unlimited

INSTITUTE FOR DEFENSE ANALYSES

1801 N. Beauregard Street, Alexandria, Virginia 22311-1772



090

UNCLASSIFIED

IDA Log No. HQ 87-032794

DEFINITIONS

IDA publishes the following documents to report the results of its work.

Reports

Reports are the most authoritative and most carefully considered products IDA publishes. They normally embody results of major projects which (a) have a direct bearing on decisions affecting major programs, (b) address issues of significant concern to the Executive Branch, the Congress and/or the public, or (c) address issues that have significant economic implications. IDA Reports are reviewed by outside panels of experts to ensure their high quality and relevance to the problems studied, and they are released by the President of IDA.

Group Reports

Group Reports record the findings and results of IDA established working groups and panels composed of senior individuals addressing major issues which otherwise would be the subject of an IDA Report. IDA Group Reports are reviewed by the senior individuals responsible for the project and others as selected by IDA to ensure their high quality and relevance to the problems studied, and are released by the President of IDA.

Papers

Papers, also authoritative and carefully considered products of IDA, address studies that are narrower in scope than those covered in Reports. IDA Papers are reviewed to ensure that they meet the high standards expected of refereed papers in professional journals or formal Agency reports.

Memorandum Reports

IDA Memorandum Reports are used for the convenience of the sponsors or the analysts to record substantive work done in quick reaction studies and major interactive technical support activities; to make available preliminary and tentative results of analyses or of working group and panel activities; to forward information that is essentially unanalyzed and unevaluated; or to make a record of conferences, meetings, or briefings, or of data developed in the course of an investigation. Review of Memorandum Reports is suited to their content and intended use.

The results of IDA work are also conveyed by briefings and informal memoranda to sponsors and others designated by sponsors, when appropriate.

The work reported in this document was conducted under contract MDA 903 84 C 0031 for the Department of Defense. The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

This Memorandum Report is published in order to make available the material it contains for the use and convenience of interested parties. The material has not necessarily been completely evaluated and analyzed, nor subjected to IDA review.

© 1986 Institute for Defense Analyses

The Government of the United States is granted an unlimited license to reproduce this document.

Approved for public release, unlimited distribution. Unclassified.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 1988	Final
4. TITLE AND SUBTITLE Ada Validation Workload		5. FUNDING NUMBERS MDA 903 84 C 0031 T-D5-304
6. AUTHOR(S) Audrey A. Hook, R. Danford Lehman		
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute for Defense Analyses (IDA) 1801 N. Beauregard Street Alexandria, VA 22311-1772		8. PERFORMING ORGANIZATION REPORT NUMBER IDA Memorandum Report M-376
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Ada Joint Program Office Room 3E114, The Pentagon Washington, D.C. 20301-3081		10. SPONSORING/MONITORING AGENCY REPORT NUMBER
11. SUPPLEMENTARY NOTES		
12a. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, unlimited distribution.		12b. DISTRIBUTION CODE 2A
13. ABSTRACT (Maximum 200 words) IDA Memorandum Report M-376, Ada Validation Workload, provides the Ada Joint Program Office (AJPO) with an analysis of the validation workload for Ada compilers and the problems surrounding the annual expiration of an Ada Compiler Validation Capability (ACVC) version. This document is intended for those individuals in the AJPO who develop the policy and procedures that govern the validation process. It focuses on the Ada Validation Facilities' (AVFs) workload associated with validations under the ACVC version 1.8. A projection of workload growth has been excluded from this analysis.		
14. SUBJECT TERMS Ada Programming Language; Validation; Compilers; Ada Compiler Validation Capability (ACVC); Ada Validation Facility (AVF).		15. NUMBER OF PAGES 28
		16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified
		20. LIMITATION OF ABSTRACT SAR

UNCLASSIFIED

IDA MEMORANDUM REPORT M-376

Ada VALIDATION WORKLOAD

**Audrey A. Hook
R. Danford Lehman**

January 1988



INSTITUTE FOR DEFENSE ANALYSES

**Contract MDA 903 84 C 0031
Task T-D5-304**

UNCLASSIFIED

UNCLASSIFIED

TABLE OF CONTENTS

PREFACE	ix
1.0 PURPOSE.....	1
2.0 SCOPE.....	1
3.0 BACKGROUND	1
4.0 FINDINGS, DISCUSSIONS AND CONCLUSIONS.....	3
4.1 Vendor Behavior	3
4.1.1 Finding.....	3
4.1.2 Discussion.....	3
4.1.3 Conclusions	4
4.2 Alternate Practices	5
4.2.1 Finding.....	5
4.2.2 Discussion	5
4.2.2.1 Extended Certificate Life	5
4.2.2.2 Limited Provision for Late Validation.....	6
4.2.2.3 Fixed 12-Month Certificate.....	6
4.2.3 Conclusions	6
4.3 AVF Workload.....	7
4.3.1 Finding.....	7
4.3.2 Discussion	7
4.3.3 Conclusion.....	8
5.0 RECOMMENDATIONS.....	9
5.1 Limited Provision for Late Validation	9
5.2. Fixed 12-Month Certificate	10
5.3 AVF Workload	11

UNCLASSIFIED

UNCLASSIFIED

LIST OF FIGURES

Figure 1 Validations Per ACVC Version	2
Figure 2 Validation Demand for ACVC 1.8	2
Figure 3 Estimate of Contractor Personnel.....	8



Accession For	
NTIS GRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By _____	
Distribution/ _____	
Availability Codes	
Dist	Avail and/or Special
A-1	

UNCLASSIFIED

UNCLASSIFIED

PREFACE

This work partially fulfills requirements of IDA Task T-D5-304, Ada Validation, for support to the Ada Joint Program Office through analysis of technical or management issues within the Ada compiler validation process.

UNCLASSIFIED

UNCLASSIFIED

1.0 PURPOSE

The purpose of IDA Memorandum Report M-376, *Ada Validation Workload*, is to provide the Ada Joint Program Office (AJPO) with an analysis of the validation workload for Ada compilers and the problems surrounding the annual expiration of an ACVC version. This report is intended for those individuals in the AJPO who develop the policy and procedures that govern the validation process.

2.0 SCOPE

This paper focuses on the Ada Validation Facilities (AVFs) workload associated with validations under Ada Compiler Validation Capability (ACVC) version 1.8. A projection of workload growth has been excluded from this analysis. Section 3 presents the background and date supporting the assertion that there is a serious imbalance in the Ada Validation Facility workload. Section 4 discusses findings concerning this imbalance and Section 5 provides recommendations for changes to the Validation Procedures and Guidelines and to the AVF workforce that will improve the management of that workload.

3.0 BACKGROUND

Issuance of the AJPO Validation Procedures and Guidelines (Version 1.1) indicates that the process of validating Ada compilers has become a relatively stable set of procedures. These procedures have undergone continual refinements since the inception of validation. However, as much as usage and analysis have identified and eliminated past problems with the process, one long-standing problem remains. This problem is the concentration of most of the validation work in the three months surrounding the annual expiration of the ACVC version on 31 May. The second calendar quarter (April, May, and June) constitutes a critical period of intense demand on the resources of the Certification Body. This concentration of demand strains the process's human resources and aggravates its incident problems.

UNCLASSIFIED

The demand for validation and re-validation services has increased significantly with each ACVC version since version 1.6. The total number of validations completed during the life of each ACVC version is shown in Figure 1. Even though the number of AVFs has also increased from one to five, the greatest demand for validation and revalidation services is not evenly distributable among these five AVFs.

Figure 1 Validations Per ACVC Version

1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
3	0	3	8	7	22	41	122

Of the 122 validations completed using ACVC 1.8, about two thirds of the validations were conducted after 1 April by three AVFs. Nearly three quarters of all the validation work was done from March through June (see Figure 2).

Figure 2 Validation Demand for ACVC 1.8

Wright-Patterson AFB, USA.							
IABG, Fed. Rep. of Germany							
BNI/AFNOR, France							
GSA/NBS, U.S.A.							
NCC, U.K.							
JUN	0	0	0	0	0	0	
JUL	0	0	0	0	0	0	
AUG	1	0	0	0	0	1	1 (3-month subtotal)
SEP	0	0	0	1	1	2	
OCT	0	0	0	0	3	3	
NOV	0	1	0	0	2	3	8
DEC	4	0	5	0	4	13	
JAN	0	0	0	0	2	2	
FEB	0	2	0	2	4	8	23
MAR	0	0	0	2	7	9	
APR	2	2	0	0	6	10	
MAY	3	2	2	1	9	17	36
JUN	13	10*	0	0	31	54*	54 (* 1 JUL test included)
Totals:	23	17	7	6	69	122	

UNCLASSIFIED

Why is there a critical period of heavy validation demand surrounding the expiration of an ACVC version? What can be done to re-distribute or manage this demand? This document addresses these questions, analyzes the surrounding issues, and proposes several solutions.

4.0 FINDINGS, DISCUSSIONS AND CONCLUSIONS

In Section 4.0, we present the findings, discussion, and conclusions concerning the factors that contribute to the critical demand period, the probable limit on human resources that can be available during this period, and procedural changes that might motivate vendors to schedule validation earlier in an ACVC version life. Pertinent pages from the *Ada Validation Procedures and Guidelines* have been included in Appendix A.

4.1 VENDOR BEHAVIOR

4.1.1 Finding

During ACVC 1.8, vendor behavior indicates that there is a tendency to validate or re-validate as late as possible in the ACVC version life. Sections 4.1 and 4.2 are being interpreted as official permission to complete validation with an expired ACVC version if vendors can show the AVF that they have used that version for pre-validation testing before it expired (31 May). (See Appendix A for the specific parts of Sections 4.1 and 4.2 that address scheduling, use of an expired ACVC, and automatic extension of certificates.)

4.1.2 Discussion

The Procedures and Guidelines Section 4.1 is being interpreted to mean that a compiler vendor may be permitted to validate a compiler using an expired version of the ACVC if the vendor has submitted pre-validation materials to the AVF before 1 June. This interpretation ignores the requirement that "the AVF has had sufficient time to determine that there are no failures."¹ AVF experience indicates that, on the average, at least two

¹ Ada Compiler Validation Procedures and Guidelines, Version 1.1, 1 January 1987, p. 10, Section 4.1.4.

UNCLASSIFIED

weeks should be allowed for analysis, resolution of issues, and preparation of the draft validation summary report (VSR) for Ada Joint Program Office/Ada Validation Organization (AJPO/AVO) review and comment. The number of validations completed after 31 May (with an expired test suite) indicates that several AVFs imposed the 31 May deadline for submission of pre-validation materials but performed analysis of these materials later.

Section 4.2 requires that a vendor submit a compiler for revalidation in a timely manner (as defined in Section 4.1, Step 4, page 10), in order to qualify for automatic extension of the validation certificate (VC). Thus the Procedures and Guidelines require that the vendor give consideration to the time estimates given in Section 4.1 for completing the validation process, including issuing a certificate. However, some vendors wishing to re-validate have not reflected this consideration of the time required to analyze pre-validation materials and to complete the subsequent steps leading to a certificate.

Of the 43 re-validations under ACVC 1.8, 18 were done after the expiration of the VC. Of the 24 revalidations that took place one month or more prior to the expiration of a VC, 9 of these were early re-validation under ACVC version 1.8 rather than version 1.9 with its increased coverage. Another 5 revalidations were performed just prior to the end of the 3-month extension period that all 1.6 VCs received. Only 10 of these 24 revalidations were performed significantly in advance of the compiler's VC.

In the pre-April period, the validation workload was evenly divided between new validations and revalidations. In the critical period, revalidations numbered about the same as before; however, the bulk of the demand during the last quarter was for testing compilers that had not been validated before. When vendors encountered development problems, it was necessary to re-schedule validation even later. There was some indication that even experienced vendors planned first-time validations as late as possible.

4.1.3 Conclusions

- The Procedures and Guidelines document is being interpreted in a way that permits informal extensions of the 12-month ACVC version life.
- The vendor demand pattern evident during ACVC 1.8 (and 1.7) will persist in subsequent ACVC cycles. Since there is no incentive for early validation and

UNCLASSIFIED

re-validation, testing under ACVC 1.9 will be concentrated in the last quarter and continue through July, or later.

4.2 ALTERNATIVE PRACTICES

4.2.1 Finding

The AJPO should consider feasible approaches for reducing vendor tendencies to schedule late and for reducing peak AVF workloads caused by the expiration of an ACVC version.

4.2.2 Discussion

We have found that three approaches are feasible. They are:

- extending certificate life;
- providing for late validation; and,
- fixing certificate expiration dates.

4.2.2.1 Extended Certificate Life

The extended certificate life approach attempts to use exhibited vendor behavior to more evenly distribute the demand for services. Since new vendors can be expected to validate as late as possible in the ACVC version life, we can leave this period open for new vendors by issuing a certificate that expires later than 12 months from the date of issue (e.g., 16 months). The central idea is to issue a certificate that has a longer life than the ACVC version so that certificates issued at one point in the ACVC version cycle will expire at a different point. Although the present year's large number of critical-period validations would still present a concentrated demand for re-validation, this demand would come at a different point in the ACVC cycle from the expected heavy demand for new validations. The peaks in demand for re-validation may begin to even out as some vendors rely on automatic extensions of their certificates to do re-validations at a later date. However, the concentration of re-validation workload is not likely to be significantly dispersed throughout the year.

UNCLASSIFIED

4.2.2.2 Limited Provision for Late Validation

This alternative provides conditions for using an ACVC test suite version after its expiration date. It is intended to remove a particular date from being the focus of last-minute validation efforts by allowing additional time for vendors to complete their implementation while imposing a reduction in the life of the validation certificate that can be received as a result of using an expired versions of the ACVC for validation.

In this alternative, disputed tests must be submitted by the vendor before expiration of the ACVC version that will be used for validation. Pre-validation materials may be submitted to the AVF after the expiration date of the ACVC version, but these materials must reflect the AVO resolution of any disputed tests. On-site testing should begin within a month following submission of the pre-validation materials. If on-site testing completes successfully, the vendor will be awarded a validation certificate with an expiration date that is equal to the test suite version's expiration date plus one year. It is expected that this provision for late validation will not be used repeatedly by a vendor. The AVF can discourage vendors from habitual late validation through contract negotiations.

The certification body (AJPO, AVO, AVFs) may define other conditions to be met in order to qualify for late validation. For example, it may be desirable to establish a cut-off date for submission of a letter of intent, or for submission of pre-validation materials, or for completing on-site testing. These deadlines may be desirable so that an AVF can arrange to preserve its capability to use the expired ACVC without impact on validations with the current ACVC. The late validation alternative is limited by the requirement for submission of disputed tests before the ACVC version expires and may include other deadlines that can be imposed by the certification body.

4.2.2.3 Fixed 12-Month Certificate

The fixed 12-month certificate approach addresses the vendor tendency to schedule validation near or after the expiration date of an existing certificate. With this alternative, the expiration date of a certificate is always 12 months from the expiration date of the previous certificate (rather than 12 months from the date of issue as is the current practice). Vendors who validate earlier than the expiration date do not lose some period of validated status under a current certificate. Vendors who wait to schedule until just before or after a certificate expiration date do not gain the additional time granted by an automatic extension because the new certificate expiration date will be fixed at 12 months from the expiration

UNCLASSIFIED

date of the old certificate. Thus vendors with current validation certificates would be less motivated to schedule later and might start validation earlier. This motivation can be reinforced by requiring the vendor to schedule or begin on-site testing prior to the expiration of the current certificate in order to qualify for an automatic extension.

4.2.3 Conclusions

The Extended Certificate Life alternative will help segregate workloads for re-validations from validation of new implementations, but does not directly address vendor tendency to schedule late in an ACVC version life or after expiration of a VC. Limited Provision for Late Validation and the Fixed 12-month Certificate alternatives, taken together, provide motivation for vendors to cooperate with AVFs in managing workload schedules. Thus vendor motivation is in the form of disincentives for delays in scheduling and completing validation.

4.3 AVF WORKLOAD

4.3.1 Finding

The three AVFs with the heaviest workloads are those that have, or soon will have contracts in place, for validation services of Ada compilers. Only one of these AVFs can augment the workforce during the critical period.

4.3.2 Discussion

Contractor support for validation services is intended to provide personnel who are skilled in analytical and on-site testing procedures for one or more programming languages. These contracts provide an AVF with a labor pool but there is some limit as to the numbers of people with experience in Ada validation who can be available during the peak workload period for Ada validation. Figure 3 is an estimate of the number of contractor personnel that can be used by AVFs to perform technical tasks associated with Ada compiler validation.

UNCLASSIFIED

Figure 3 Estimate of Contractor Personnel

AVF	No. of Contractors
Wright-Patterson Air Force Base	16
National Bureau of Standards (NBS)	6 (projected)
Ministry of Defense, UK	<u>8</u> (projected)
	30

Wright-Patterson uses these contractor personnel in teams consisting of two people per validation projects with each team is capable of completing one project per month. At NBS and in the UK, teams are generally not used. The analyst hours per validation project can vary from 150 to 350 hours; however, on the average, the output for NBS and the UK is one validation project per person-month (14 per month). Thus the combined validation service capacity for these three AVFs is about 22 validation projects per month. Wright-Patterson is the only AVF that can increase the number of available teams if there is adequate lead-time to locate or train analysts. However, this expansion of resources has some limit, as yet undefined, in terms of available funds and human resources.

The demand for last quarter validation under ACVC 1.8 at these three AVFs was 82 validations. Even though this number includes several validations that were completed within a single project (requiring only one on-site visit by the AVF), the demand for ACVC 1.9 validations and re-validations will likely exceed the supply of AVF resources as new customers are added to the demand pattern. The extra workforce that Wright-Patterson may be able to obtain during the critical period will be a crucial factor in being able to accommodate the workload for ACVC 1.9. The establishment of an additional AVF in the U.S., with a contract modeled on the current Wright-Patterson contracting vehicle, would provide more flexibility not only for peak workload periods but also for meeting an overall increase in workload.

4.3.3 Conclusion

The capability of the AVFs in the US and in the UK to accommodate an expanding workload for Ada validation services is limited. Concentration of demand during the critical period in 1988 will expose these limitations.

UNCLASSIFIED

5.0 RECOMMENDATIONS

5.1 LIMITED PROVISION FOR LATE VALIDATION

Permit a limited use of an expired ACVC version by incorporating a Limited Provision for Late Validation in the wording of the Ada Validation Procedures and Guidelines, paragraph 4.1. The following revised wording is proposed: (the new wording has been italicized.)

Paragraph 4.1 STEPS AND PROCEDURES. There are nine steps in *the Ada VALIDATION process* that a VENDOR and the CERTIFICATION BODY must successfully complete. *It is expected that the first seven of these steps will be completed prior to the expiration of the ACVC version that is used in VALIDATION testing.* These steps are:

Paragraphs 4.1.1 through 4.1.3 - no change.

Paragraphs 4.1.4 - Last paragraph within 4.1.4 (ref. page 10, Ada Validation Procedures and Guidelines).

In the event that a VENDOR completes step three in the VALIDATION process (i.e., Negotiate a formal agreement and submit disputed ACVC tests) prior to the expiration date of the current ACVC, and that the expiration date is subsequently reached before the VALIDATION process is complete, then the VENDOR is allowed to proceed with the original ACVC provided that:

- a. *The AVF determines that there are no failures of APPLICABLE ACVC TESTS, and*
- b. *the VENDOR does not submit test disputes after the expiration of the ACVC version that will be used for validation, and*
- c. *the AVF agrees to complete the VALIDATION process after giving consideration to already scheduled work.*

UNCLASSIFIED

Completing the VALIDATION after the expiration of an ACVC version is a late VALIDATION. It is intended that there will be a limited use of the provision for late VALIDATION by VENDORS. The AVF may impose additional conditions that must be met by the VENDOR to ensure that a VENDOR does not habitually rely on late VALIDATION.

5.2 FIXED 12-MONTH CERTIFICATE

Provide explicit qualifying conditions for an automatic extension of a VALIDATION CERTIFICATE by incorporating a Fixed 12-Month Certificate in the wording of Section 4.2. The following wording is offered for consideration. Changes to the current wording have been italicized.

Paragraph 4.2 CERTIFICATE EXPIRATION. VALIDATION CERTIFICATES expire in accordance with the time period established by the Director, AJPO. This time period is currently one year after the date of issue *when the VENDOR has completed step 7 of the VALIDATION process prior to expiration of the ACVC version used for VALIDATION.* Subsequent VALIDATION CERTIFICATES issued for this BASE COMPILER will have an expiration date that is fixed at one time period beyond that of the previous VALIDATION CERTIFICATE when the VENDOR has completed step 7 of the VALIDATION process prior to the expiration date of the ACVC version used for VALIDATION. When a VENDOR has completed step 7 of the VALIDATION process after the expiration date of the ACVC version used for VALIDATION, the expiration date of the VALIDATION CERTIFICATE will be one time period beyond the expiration date of the ACVC.

A BASE COMPILER and associated DERIVED COMPILERS will be removed from the list of VALIDATED Ada COMPILERS when the VALIDATION CERTIFICATE for the BASE COMPILER expires. The VENDOR may request that the AJPO not remove the BASE COMPILER and associated DERIVED COMPILERS from the list of VALIDATED Ada COMPILERS when the VENDOR has:

UNCLASSIFIED

- a. *begun step 7 of the VALIDATION process prior to the expiration date of the VALIDATION CERTIFICATE for the BASE COMPILER, or*
- b. *requested an AVF to schedule step 7 prior to the expiration date of the VALIDATION CERTIFICATE for the BASE COMPILER but has been delayed because the AVF had prior commitments for VALIDATION.*

It is the intent of the CERTIFICATION BODY that VENDORS schedule the REVALIDATION of their VALIDATED COMPILERS to occur in advance of the expiration of the associated VALIDATION CERTIFICATE. By applying a rule for establishing the expiration date at a fixed time period that is relative to the previous expiration date, a VALIDATION CERTIFICATE extends the time that an Ada COMPILER is a VALIDATED COMPILER by a fixed amount, regardless of when the actual testing occurs. Thus, all VENDORS may complete step 7 well before the expiration date of a VALIDATION CERTIFICATE without concern for redundant coverage."

5.3 AVF WORKLOAD

A decision to establish an additional AVF should be based upon analysis of the workload for ACVC 1.9. This analysis should also include the geographic distribution of clients and criteria for selecting an organizational entity that will be chartered as an AVF.

Distribution List for IDA Paper M-376

NAME AND ADDRESS	NUMBER OF COPIES
Sponsor	
Mr. John P. Solomond Director Ada Joint Program Office Room 3E114 The Pentagon Washington, D.C. 20301-3081	2
Other	
Defense Technical Information Center Cameron Station Alexandria, VA 22314	2
IIT Research Institute 4600 Forbes Blvd., Suite 300 Lanham, MD 20706 Attn. Ann Eustice	1
CSED Review Panel	
Dr. Dan Alpert, Director Program in Science, Technology & Society University of Illinois Room 201 912-1/2 West Illinois Street Urbana, Illinois 61801	1
Dr. Thomas C. Brandt 10302 Bluet Terrace Upper Marlboro, MD 20772	1
Dr. Ruth Davis The Pymatuning Group, Inc. 2000 N. 15th Street, Suite 707 Arlington, VA 22201	1
Dr. C.E. Hutchinson, Dean Thayer School of Engineering Dartmouth College Hanover, NH 03755	1

NAME AND ADDRESS	NUMBER OF COPIES
Mr. A.J. Jordano Manager, Systems & Software Engineering Headquarters Federal Systems Division 6600 Rockledge Dr. Bethesda, MD 20817	1
Dr. Ernest W. Kent Philips Laboratories 345 Scarborogh Road Briarcliff Manor, NY 10510	1
Dr. John M. Palms, President Georgia State University University Plaza Atlanta, GA 30303	1
Mr. Keith Uncapher University of Southern California Olin Hall 330A University Park Los Angeles, CA 90089-1454	1
IDA	
General W.Y. Smith, HQ	1
Mr. Philip Major, HQ	1
Dr. Robert E. Roberts, HQ	1
Ms. Anne Douville, CSED	1
Mr. Terry Mayfield, CSED	1
Ms. Audrey A. Hook, CSED	2
Mr. R. Danford Lehman, CSED	2
Ms. Katydean Price, CSED	2
Dr. Richard L. Wexelblat, CSED	1
IDA Control & Distribution Vault	3